IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: Ulrich Neumann et al.	Art Unit	: 2628
Serial No.	: 10/676,377	Examiner	: Javid A. Amini
Filed	: September 30, 2003	Conf. No.	: 3241
Title	: MODELING AND VIDEO PROJECTION FOR AUGMENTED VIRTUAL ENVIRONMENTS		

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

BRIEF ON APPEAL

Sir:

Applicant herewith files this brief on appeal under 37 CFR 41.37, thereby perfecting the notice of appeal which was originally filed on October 14, 2008.

(1) Real Party in Interest

This application is assigned of record to the University of Southern California who is hence the real party in interest.

(2) Related Appeals and Interferences

There are no known related appeals or interferences.

(3) Status of Claims

Claims 1-24, 26-28, 32, 34-36, and 40 were previously cancelled. Claims 25, 29-31, 33, 37-39, and 41-50 are pending, with claims 29, 37, and 45 being independent. All of the pending claims 25, 29-31, 33, 37-39, and 41-50 stand rejected and are appealed herein.

(4) Status of Amendments

Claims 45-50 were amended in the Response filed on September 15, 2008, subsequent to the final rejection. This amendment after final has not been entered.

(5) Summary of Claimed Subject Matter

The present claims define systems and techniques relating to virtual environments in which a model of a real environment (e.g., a battlefield) can be generated in a computer system and real-time video imagery can be projected onto the computer model for use in visualizing the real world environment. Such a system can be used in different virtual environment applications, "including in engineering, mission planning, training simulations, entertainment, tactical planning, and military operations in battlefield environments."[1]

Independent claim 29 covers a method comprising:

obtaining a three dimensional model of a three dimensional environment, the three dimensional model generated from range sensor information representing a height field for the three dimensional environment;[2]

identifying in real time a region in motion with respect to a background image in real-time video imagery information from at least one image sensor having associated position and orientation information with respect to the three dimensional model, the background image comprising a single distribution background dynamically modeled from a time average of the real-time video imagery information;[3]

placing a surface that corresponds to the moving region in the three dimensional model, wherein placing the surface comprises casting a ray from an optical center, corresponding to the real-time video imagery information, to a bottom point of the moving region in an image plane in the three dimensional model, and determining a position, an orientation and a size of the surface based on the ray, a ground plane in the three dimensional model, and the moving region;[4]

projecting the real-time video imagery information onto the three dimensional model, including the surface, based on the position and orientation information;[5] and

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[1] See Specification at page 6, lines 11-16.
[2] See e.g., Specification at page 7, line 21, to page 8, line 19, ref. nos. 110, 140 and 160 in FIG. 1; at page 11, lines 9-13, ref. no. 300 in FIG. 3; and at page 11, line 21, to page 24, line 14, ref. nos. 500-550 in FIG. 5.
[3] See e.g., Specification at page 11, lines 13-15, ref. no. 310 in FIG. 3; and at page 36, line 15, to page 37, line 16, ref. no. 1510 in FIG. 15.
[4] See e.g., Specification at page 39, line 17, to page 41, line 23, ref. nos. 1600-1680 in FIG. 16.
[5] See e.g., Specification at page 11, lines 16-18, ref. no. 320 in FIG. 3.

visualizing the three dimensional model with the projected real-time video imagery;[6]

wherein identifying a region in motion in real time comprises subtracting the background image from the real-time video imagery information, identifying a foreground object in the subtracted real-time video imagery information, validating the foreground object by correlation matching between identified objects in neighboring image frames, and outputting the validated foreground object.[7]

Independent claim 37 covers an augmented virtual environment system comprising:

an object detection and tracking component that identifies in real time a region in motion with respect to a background image in real-time video imagery information from at least one image sensor having associated position and orientation information with respect to a three dimensional model of a three dimensional environment,[8] the three dimensional model generated from range sensor information representing a height field for the three dimensional environment,[9] the background image comprising a single distribution background dynamically modeled from a time average of the real-time video imagery information,[10] and places a surface that corresponds to the moving region with respect to the three dimensional model, wherein the object detection and tracking component places the surface by performing operations comprising casting a ray from an optical center, corresponding to the real-time video imagery information, to a bottom point of the moving region in an image plane in the three dimensional model, and determining a position, an orientation and a size of the surface based on the ray, a ground plane in the three dimensional model, and the moving region;[11]

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[6] See e.g., Specification at page 11, lines 18-20, ref. no. 330 in FIG. 3.
[7] See e.g., Specification at page 36, line 15, to page 39, line 16, ref. nos. 1520-1550 in FIG. 15.
[8] See e.g., Specification at page 5, line 16, to page 6, line 10, at page 8, line 20, to page 10, line 4, at page 24, line 15, to page 29, line 9, ref. nos. 120, 130, 150 and 170 in FIG. 1, ref. no. 200 in FIG. 2; and at page 35, line 6, to page 36, line 14, ref. no. 1410 in FIG. 14.
[9] See e.g., Specification at page 7, line 21, to page 8, line 19, ref. nos. 110, 140 and 160 in FIG. 1; at page 11, lines 9-13, ref. no. 300 in FIG. 3; and at page 11, line 21, to page 24, line 14, ref. nos. 500-550 in FIG. 5.
[10] See e.g., Specification at page 36, line 15, to page 37, line 16, ref. no. 1510 in FIG. 15.
[11] See e.g., Specification at page 39, line 17, to page 41, line 23, ref. nos. 1600-1680 in FIG. 16.

a dynamic fusion imagery projection component that projects the real-time video imagery information onto the three dimensional model, including the surface, based on the position and orientation information;[12] and

a visualization sub-system that visualizes the three dimensional model with the projected real-time video imagery;[13]

wherein the object detection and tracking component identifies the moving region by performing operations comprising subtracting the background image from the real-time video imagery information, identifying a foreground object in the subtracted real-time video imagery information, validating the foreground object by correlation matching between identified objects in neighboring image frames, and outputting the validated foreground object.[14]

Independent claim 45 covers a machine-readable medium embodying information indicative of instructions for causing one or more machines to perform operations comprising:

obtaining a three dimensional model of a three dimensional environment, the three dimensional model generated from range sensor information representing a height field for the three dimensional environment;[15]

identifying in real time a region in motion with respect to a background image in real-time video imagery information from at least one image sensor having associated position and orientation information with respect to the three dimensional model, the background image comprising a single distribution background dynamically modeled from a time average of the real-time video imagery information;[16]

placing a surface that corresponds to the moving region in the three dimensional model, wherein placing the surface comprises casting a ray from an optical center, corresponding to the real-time video imagery information, to a bottom point of the moving region in an image plane in

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[12] See e.g., Specification at page 6, line 7, to page 7, line 20, at page 10, lines 5-14, at page 29, line 10, to page 30, line 15, ref. no. 180 in FIG. 1l; and at page 35, line 22, to page 36, line 14, ref. no. 1420 in FIG. 14.
[13] See e.g., Specification at page 6, line 7, to page 7, line 20, at page 11, lines 1-8, ref. no. 190 in FIG. 1.
[14] See e.g., Specification at page 36, line 15, to page 39, line 16, ref. nos. 1520-1550 in FIG. 15.
[15] See e.g., Specification at page 7, line 21, to page 8, line 19, ref. nos. 110, 140 and 160 in FIG. 1; at page 11, lines 9-13, ref. no. 300 in FIG. 3; and at page 11, line 21, to page 24, line 14, ref. nos. 500-550 in FIG. 5.
[16] See e.g., Specification at page 11, lines 13-15, ref. no. 310 in FIG. 3; and at page 36, line 15, to page 37, line 16, ref. no. 1510 in FIG. 15.

the three dimensional model, and determining a position, an orientation and a size of the surface based on the ray, a ground plane in the three dimensional model, and the moving region;[17]

projecting the real-time video imagery information onto the three dimensional model, including the surface, based on the position and orientation information;[18] and

visualizing the three dimensional model with the projected real-time video imagery;[19]

wherein identifying a region in motion in real time comprises subtracting the background image from the real-time video imagery information, identifying a foreground object in the subtracted real-time video imagery information, validating the foreground object by correlation matching between identified objects in neighboring image frames, and outputting the validated foreground object.[20]

(6) Grounds of Rejection to be Reviewed on Appeal

I. Grounds of Rejection I

Claims 25, 29-31, 33, 37-39, and 41-50 stand rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Sawhney, H. E., et al., "Video Flashlights – Real Time Rendering of Multiple Videos for Immersive Model Visualization" (hereinafter "Sawhney").

II. Grounds of Rejection II

Claims 45-50 stand rejected under 35 U.S.C. §112, second paragraph, as allegedly being indefinite.

[17] See e.g., Specification at page 39, line 17, to page 41, line 23, ref. nos. 1600-1680 in FIG. 16.
[18] See e.g., Specification at page 11, lines 16-18, ref. no. 320 in FIG. 3.
[19] See e.g., Specification at page 11, lines 18-20, ref. no. 330 in FIG. 3.
[20] See e.g., Specification at page 36, line 15, to page 39, line 16, ref. nos. 1520-1550 in FIG. 15.

(7) Argument

I. Rejection Under 35 U.S.C. §103

A. Claims 25, 29-31, 33, 37-39, and 41-50:

The Sawhney reference describes an immersive model-based video visualization system that "provides an augmented reality solution for video surveillance and monitoring applications."[21] Sawhney describes a system that is similar to the presently claimed subject matter, but which differs in many significant respects. Thus, Sawhney fails to teach or suggest the claimed invention.

First, the Office has asserted that Sawhney teaches "placing a surface that corresponds to the moving region in the three dimensional model" and "projecting the real-time video imagery information onto the three dimensional model, **including the surface**, based on the position and orientation information", on the basis that "fig. 10 illustrates moving objects".[22] However, Figure 10 in Sawhney shows moving object detection, **not** placing a surface that corresponds to the moving region in the three dimensional model and projecting real-time video imagery information onto the three dimensional model, **including the surface**.[23] To the contrary, moving objects are represented in the three dimensional model using "blobs or icons."[24] Sawhney does state that three dimensional models of the moving object can be "rendered along with the site model"[25], but Sawhney does not state that the video information is projected onto such models.

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[21] See Sawhney at page 157.
[22] See 11-13-2007 Office Action at page 3.
[23] See Sawhney at Figure 10 and section 5, at pages 164, 165 and 167.
[24] See Sawhney at Figures 11 and 12, and section 5, at pages 165, 167 and 168.
[25] See Sawhney at section 2, page 158.

Moreover, when this 3D modeling of dynamic objects is described in Sawhney, all that is presented is 3D icons with **no video information projected thereon**.[26]

In response to this point, the Office has further referred to Figures 8d and 9 of Sawnhey stating that[27]:

> **In response to Applicant's argument (on page 9 in first paragraph) that the reference Sawhney does not state the video information is projected on to such models, Contrarily, Sawhney teaches clearly in fig. 8d, see model red lines. On pages 9-10, Applicant argues that Sawhney does not describe, placing a surface that corresponds to a moving region in a three dimensional model, Examiner believes Sawhney e.g., in fig. 9 illustrates a moving region (a moving aerial) in a 3-D model e.g., using model lines in fig. 8d.**

However, Figure 8d in Sawhney shows model lines being projected onto the image using an estimated pose of the camera, **not** projecting real-time video imagery information onto a three dimensional model **including** a surface placed into the model to correspond to a moving region identified in the real-time video imagery information.

Further, the reference to Figure 9 in Sawhney is misplaced. Figure 9 in Sawhney shows the rendering of two frames of a video captured from a moving aerial autonomous helicopter. The suggestion by the Office that the "moving aerial", which is the helicopter having a camera that **captures the video imagery**, can somehow be equated with the moving region identified **within the video imagery** itself completely defies common sense, and contradicts the other stated bases for rejecting the claims. The Advisory Action dated 10-2-2008 fails to clarify the logic behind the reference to the "moving aerial" in Sawhney or how this can serve as a basis to

[26] See Sawhney at Figure 12, and section 5, at pages 165 and 168.
[27] See 6-13-2008 Office Action at page 2.

reject the claims. Thus, Sawhney fails to teach or suggest projecting real-time video imagery information onto a surface that has been placed into a three dimensional model of a three dimensional environment in order to correspond to a region in motion identified within that very same real-time video imagery information, and the rejection should be overturned for at least this reason.

Second, claim 29 further recites, "wherein placing the surface comprises casting a ray from an optical center, corresponding to the real-time video imagery information, to a bottom point of the moving region in an image plane in the three dimensional model, and determining a position, an orientation and a size of the surface based on the ray, a ground plane in the three dimensional model, and the moving region." In the rejection of this subject matter, the Office has stated, "Examiner's note: casting rays are: cast and traced in groups based on some geometric constraints, and each ray is traced separately, so that every point (usually a pixel) on the display is traced by one ray."[28] However, the presently claimed ray casting has nothing to do with tracing pixel points on a display, as is evident in view of the plain meaning of the claim language and the Specification.[29] Rather, this claimed subject matter relates to casting a vector in the three dimensional model. The Office has also referred to Figures 5 and 6 of Sawhney, but these portions of Sawhney simply show video rendering on the site model alone, and do not relate to or describe placing a surface that corresponds to a moving region in a three dimensional model.

Furthermore, with respect to "determining a position, an orientation and a size of the surface based on the ray, a ground plane in the three dimensional model, and the moving region",

[28] See 6-13-2008 Office Action at page 5.
[29] See e.g., Specification at page 39, line 17, to page 41, line 23, and at FIG. 16.

the Office states, "fig. 10 illustrates a 3D model, and a moving region."[30] With all due respect to the Office, Figure 10 and its corresponding description discloses moving object detection, but says nothing about determining a position, an orientation and a size of a surface that is placed in a three dimensional model, let alone "casting a ray from **an optical center**, corresponding to the real-time video imagery information, to **a bottom point of the moving region** in an image plane in the three dimensional model." In fact, the only technique described in Sawhney for modeling a moving object is to use "stereo depth information" from "stereo cameras",[31] which does not in any way teach or suggest "placing a surface that corresponds to the moving region in the three dimensional model, wherein placing the surface comprises casting a ray from **an optical center**, corresponding to the real-time video imagery information, to **a bottom point of the moving region** in an image plane in the three dimensional model, and determining a position, an orientation and a size of the surface based on **the ray**, **a ground plane** in the three dimensional model, and **the moving region**."

Thus, Sawhney fails to teach or suggest this subject matter, as claimed, and the rejection of claim 29 should be overturned for at least this additional reason. Similar arguments are applicable to independent claims 37 and 45. Thus, for all of the above reasons, Ground of Rejection I should be overturned.

B. Claims 41, 43, and 49:

Claims 41, 43 and 49 each recite, "wherein identifying a foreground object comprises identifying the foreground object in the subtracted real-time video imagery information using a

[30] See 6-13-2008 Office Action at page 5.
[31] See Sawhney at sections 2 and 5, at pages 158 and 165.

histogram-based threshold and a noise filter." The cited portion of Sawhney clearly describes the use of a threshold applied to a difference image between a current image and a median of a stack of images.[32] Sawhney does not indicate that the threshold is histogram-based or that a noise filter is used. In response, the Office has referred to page 164 and Sawhney's teaching that "the absolute value at each point can then be computed, and the result can be thresholded in order to highlight intensity or feature differences between the current video image and the reference image[.]"[33] But the Office has failed to explain how this teaching of Sawhney is considered to teach the use of a **histogram-based** threshold. Since Sawhney fails to teach or suggest this feature of the claim, the rejection should be overturned for at least this reason.

Furthermore, the Office's interpretation that "a noise filter" may be considered "as a virtual camera view in fig. 3"[34] is without rational basis. In response to this point, the Office has referred to page 160 and Figure 3 of Sawhney, asserting that such "clearly illustrates final rendered composite that has been filtered the video pixels."[35] But this does not address the claimed subject matter, which requires the use of a noise filter **in the process of identifying a foreground object**. Sawhney never describes such a use of a noise filter.[36] Thus, the rejection should be overturned for at least this additional reason.

In view of these further arguments, Ground of Rejection I should be overturned with respect to claims 41, 43 and 49.

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[32] See Sawhney at Figure 10 and section 5, at page 164 and 167.
[33] See 6-13-2008 Office Action at pages 2-3.
[34] See 11-13-2007 Office Action at page 4.
[35] See 6-13-2008 Office Action at page 3.
[36] See Sawney in section 5, at pages 164-165.

C. Claims 42, 44, and 50:

Claims 42, 44 and 50 each recite, "wherein identifying a region in motion in real time further comprises estimating the background image by modeling the background image as a temporal pixel average of five recent image frames in the real-time video imagery information." With respect to this subject matter, the Office "takes an official notice for an average of five recent frames, because Sawhney on page 161 under 'A pseudo-code for the rendering algorithm ..' teaches as one of the parameters that a user may be indicated a number for number of frames 'frame number', and that number may be 5 image frames."[37] This official notice was explicitly challenged. The "Frame Number" here is a parameter to the "UpdateVideoContent" procedure, which clearly relates to retrieving the most recent available video data from a camera specified by "Video Source". Contrary to the Office's assertion, nothing in Sawhney suggests that this procedure is part of the process of moving object detection or that the "Frame Number" may be an indication to use five recent image frames to generate a temporal pixel average to model the background image.

Furthermore, taking official notice regarding this claimed subject matter is inappropriate since the Office has previously contended that "applicant has established criticality for the use of five frames in the averaging technique" and "optimizing such a number of frames would require undue experimentation under *In re Wands*, since applicant points out that five frames has a specific benefit, as per the specification."[38] In response to these points, the Office states[39]:

> (e.g., on page 164 at right col. teaches the reference background image needs to be constantly updated during the day to reflect changing ambient illumination.

[37] See 11-13-2007 Office Action at page 4.
[38] See 11-28-2005 Office Action at page 6.
[39] *See* 6-12-2008 Office Action at page 3.

> Alternatively only moving objects may be detected by comparing current image with an image taken a few seconds before. The 2D moving object detection can be done in real time, also see page 162 left column at third paragraph). On the other hand, comparing fig. 15 of the current invention with fig. 10 of the reference: in fig. 15 steps 1500, 1510, 1520, and 1530 illustrate what is shown the left side of fig. 10, and fig. 10 illustrates the validated foreground object in step 1550 in the middle of fig. 10.

None of these points by the Office actually address the argument regarding the Office's official notice. Since the Office has admitted that Sawhney does not teach "estimating the background image by modeling the background image as a temporal pixel average of five recent image frames in the real-time video imagery information", and since the Office's taking of official notice cannot be reconciled with the Office's prior assertions that "applicant has established criticality for the use of five frames in the averaging technique" and "optimizing such a number of frames would require undue experimentation under *In re Wands*, since applicant points out that five frames has a specific benefit, as per the specification", the rejection should be overturned.

In view of these further arguments, Ground of Rejection I should be overturned with respect to claims 42, 44 and 50.

II. Rejection Under 35 U.S.C. §112

Claims 45-50 were rejected under 35 U.S.C. §112, second paragraph, as allegedly being indefinite. The Office stated that, "the machine-readable medium is not well established whether is a camera, a computer or an optical device. The limitation of 'medium' is not explicitly

defined whether is a storage device, or a signal, etc."[40] An amendment to claims 45-50 was presented in the Response filed on September 15, 2008, to obviate the rejection by replacing "medium" with "storage device" (without conceding the propriety of the rejection). The Advisory Action dated 10-2-2008 did not specify whether or not the amendment had been entered, but during a telephone call on January 13, 2009, Examiner Amini indicated that the amendment had not been entered. When asked why, Examiner Amini indicated that he should have objected to the specification, rather than reject the claims. In light of this, and in light of the facts that (1) the plain meaning of the phrase "machine-readable medium" is well established in view of the original application as filed and the knowledge of those of ordinary skill in the art, and (2) the Specification never suggests that a "medium" can be a "signal", Ground of Rejection II should be overturned.

Please apply the appeal brief fee, the extension of time fee, and any other necessary charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

Date: Jan. 14, 2009

William E. Hunter
Reg. No. 47,671

Fish & Richardson P.C.
PTO Customer No. 20985
Telephone: (858) 678-5070
Facsimile: (877) 769-7945

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[40] See 6-13-2008 Office Action at page 9.

Appendix of Claims

25. The method of claim 29, wherein the surface comprises a two dimensional surface.

29. A method comprising:

obtaining a three dimensional model of a three dimensional environment, the three dimensional model generated from range sensor information representing a height field for the three dimensional environment;

identifying in real time a region in motion with respect to a background image in real-time video imagery information from at least one image sensor having associated position and orientation information with respect to the three dimensional model, the background image comprising a single distribution background dynamically modeled from a time average of the real-time video imagery information;

placing a surface that corresponds to the moving region in the three dimensional model, wherein placing the surface comprises casting a ray from an optical center, corresponding to the real-time video imagery information, to a bottom point of the moving region in an image plane in the three dimensional model, and determining a position, an orientation and a size of the surface based on the ray, a ground plane in the three dimensional model, and the moving region;

projecting the real-time video imagery information onto the three dimensional model, including the surface, based on the position and orientation information; and

visualizing the three dimensional model with the projected real-time video imagery;

wherein identifying a region in motion in real time comprises subtracting the background image from the real-time video imagery information, identifying a foreground object in the subtracted real-time video imagery information, validating the foreground object by correlation matching between identified objects in neighboring image frames, and outputting the validated foreground object.

30. The method of claim 29, further comprising tracking the position and orientation information of the at least one image sensor in the environment with respect to the three dimensional model in real-time.

31. The method of claim 30, wherein obtaining a three dimensional model of a three dimensional environment comprises generating the three dimensional model of the three dimensional environment.

33. The system of claim 37, wherein the surface comprises a two dimensional surface.

37. An augmented virtual environment system comprising:

an object detection and tracking component that identifies in real time a region in motion with respect to a background image in real-time video imagery information from at least one image sensor having associated position and orientation information with respect to a three dimensional model of a three dimensional environment, the three dimensional model generated from range sensor information representing a height field for the three dimensional environment, the background image comprising a single distribution background dynamically modeled from a time average of the real-time video imagery information, and places a surface that corresponds to the moving region with respect to the three dimensional model, wherein the object detection and tracking component places the surface by performing operations comprising casting a ray from an optical center, corresponding to the real-time video imagery information, to a bottom point of the moving region in an image plane in the three dimensional model, and determining a position, an orientation and a size of the surface based on the ray, a ground plane in the three dimensional model, and the moving region;

a dynamic fusion imagery projection component that projects the real-time video imagery information onto the three dimensional model, including the surface, based on the position and orientation information; and

a visualization sub-system that visualizes the three dimensional model with the projected real-time video imagery;

wherein the object detection and tracking component identifies the moving region by performing operations comprising subtracting the background image from the real-time video imagery information, identifying a foreground object in the subtracted real-time video imagery

information, validating the foreground object by correlation matching between identified objects in neighboring image frames, and outputting the validated foreground object.

38. The system of claim 37, further comprising a tracking sensor system that integrates visual input, global navigational satellite system receiver input, and inertial orientation sensor input to obtain the position and the orientation information associated with the at least one image sensor in real time in conjunction with the real-time video imagery.

39. The system of claim 38, further comprising a model construction component that generates the three dimensional model of the three dimensional environment.

41. The method of claim 29, wherein identifying a foreground object comprises identifying the foreground object in the subtracted real-time video imagery information using a histogram-based threshold and a noise filter.

42. The method of claim 41, wherein identifying a region in motion in real time further comprises estimating the background image by modeling the background image as a temporal pixel average of five recent image frames in the real-time video imagery information.

43. The system of claim 37, wherein identifying a foreground object comprises identifying the foreground object in the subtracted real-time video imagery information using a histogram-based threshold and a noise filter.

44. The system of claim 43, wherein identifying a region in motion in real time further comprises estimating the background image by modeling the background image as a temporal pixel average of five recent image frames in the real-time video imagery information.

45. A machine-readable medium embodying information indicative of instructions for causing one or more machines to perform operations comprising:

obtaining a three dimensional model of a three dimensional environment, the three dimensional model generated from range sensor information representing a height field for the three dimensional environment;

identifying in real time a region in motion with respect to a background image in real-time video imagery information from at least one image sensor having associated position and orientation information with respect to the three dimensional model, the background image comprising a single distribution background dynamically modeled from a time average of the real-time video imagery information;

placing a surface that corresponds to the moving region in the three dimensional model, wherein placing the surface comprises casting a ray from an optical center, corresponding to the real-time video imagery information, to a bottom point of the moving region in an image plane in the three dimensional model, and determining a position, an orientation and a size of the surface based on the ray, a ground plane in the three dimensional model, and the moving region;

projecting the real-time video imagery information onto the three dimensional model, including the surface, based on the position and orientation information; and

visualizing the three dimensional model with the projected real-time video imagery;

wherein identifying a region in motion in real time comprises subtracting the background image from the real-time video imagery information, identifying a foreground object in the subtracted real-time video imagery information, validating the foreground object by correlation matching between identified objects in neighboring image frames, and outputting the validated foreground object.

46. The machine-readable medium of claim 45, wherein the surface comprises a two dimensional surface.

47. The machine-readable medium of claim 45, further comprising tracking the position and orientation information of the at least one image sensor in the environment with respect to the three dimensional model in real-time.

48. The machine-readable medium of claim 47, wherein obtaining a three dimensional model of a three dimensional environment comprises generating the three dimensional model of the three dimensional environment.

49. The machine-readable medium of claim 45, wherein identifying a foreground object comprises identifying the foreground object in the subtracted real-time video imagery information using a histogram-based threshold and a noise filter.

50. The machine-readable medium of claim 45, wherein identifying a region in motion in real time further comprises estimating the background image by modeling the background image as a temporal pixel average of five recent image frames in the real-time video imagery information.

Evidence Appendix

None.

Related Proceedings Appendix

None.